Online Resources for When Treatments Are Tweets: A Network Mobilization Experiment Over Twitter

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Appendix 1

The treatment-by-treatment analysis of the heterogeneous effects of the tweet encouragement in Sections 6 and 7 relied on an assumption that all subjects who signed the petition in the organizer treatment would have done so in the followers treatment as well. This assumption is not guaranteed to hold if there are some subjects who would only respond to one treatment or the other. Table A1 describes the eight theoretically possible types of subjects. The first type, for example, would sign the petition regardless of treatment condition. The second type, however, would only sign the petition if assigned to the public tweet or the organizer direct message treatments—but not if assigned to the follower condition.

Table A1: Possible Subject Types

Type	Public Tweet Only	Organizer	Follower	Population Proportion
1	1	1	1	$\pi_1 = 0$
2	1	1	0	$\pi_2 = 0$
3	1	0	1	$\pi_3 = 0$
4	1	0	0	$\pi_4 = 0$
5	0	1	1	$\pi_5 = ?$
6	0	1	0	$\pi_6 = ?$
7	0	0	1	$\pi_7 = ?$
8	0	0	0	$\pi_8 = [0.955, 0.965]$

We know that the proportions of types 1 through 4 in the population are all equal to zero: no subjects in the public tweet conditions signed the petitions. Together, types 5 though 7 account for approximately 3.6% of the population in Study 1 and approximately 4.5% of the population in Study 2; type 8 accounts for the remainder.

The crucial question for us is the proportion of types 6 and 7, π_6 and π_7. If they are both equal to zero, then we induce no bias when we condition on DM type in the second-stage experiment. If, however, there are 6's or 7's that sign the petition, then conditioning would in fact induce bias. What evidence do we have that the proportion of 6's and 7's are both equal to zero?

First, we know that equal proportions of subjects signed the petitions in the organizer and follower DM treatments. Sections 6 and 7 describe well-estimated average differences between the two conditions to be very close to zero (and certainly not statistically significantly different from zero). We can therefore infer that $\pi_6 = \pi_7$:

$$
\begin{aligned}
E[Y|Z = \text{Organizer}] &= \pi_5 + \pi_6 \\
E[Y|Z = \text{Follower}] &= \pi_5 + \pi_7 \\
E[Y|Z = \text{Organizer}] &= E[Y|Z = \text{Follower}] \\
\pi_5 + \pi_6 &= \pi_5 + \pi_7 \\
\pi_6 &= \pi_7
\end{aligned}
$$

If π_6 and π_7 did not equal zero, then they would have to exactly counterbalance one another, which is possible, but unlikely. It would be especially unlikely for $\pi_6 = \pi_7 = c > 0$ across a wide variety of subjects. A heterogeneous effects analysis of the "organizer" versus "follower" manipulation by network centrality suggested no difference in treatment effects at any level of centrality. This does not constitute conclusive proof that the only types in the population are 5's and 8's, but it is suggestive. The analyses in Sections 6 and 7 rely on this assumption and should be weighed with the plausibility of this assumption in mind.

Appendix 2: Randomization Checks

In this section, we present randomization checks for Studies 1 and 2. In particular, under random assignment of the treatment, we would expect the pre-treatment covariates to be balanced across the three treatment conditions. Equivalently, we would expect that the covariates would not predict treatment status. For each experiment, we will present three randomization checks:

1. Balance tables, presented in Tables A2 and A3. The tables present means and standard errors for four pre-treatment covariates: Account Type (male, female, organization, unknown), Number of Followers, Days on Twitter, and Eigenvector Centrality.

2. Tests of independence for each covariate, shown in the last columns of Tables A2 and A3.

    - Study 1 was carried out using complete random assignment, so we can directly apply the chi-square test to the categorical variable (Account Type) and the f-test of joint independence to the continuous variables (Number of Followers, Days on Twitter, and Eigenvector Centrality).
    - Study 2 was carried out using block random assignment, so we condition the test on the experimental block, and aggregate the tests to form a single p-value using Fisher's method (Fisher 1925, Section 21.1). Additionally, we use Fisher's exact test in lieu of the chi-square test because of the low cell count within a single stratum. The required assumption that the margins are fixed is met by design (a fixed number of treatments are allocated to a fixed distribution of account types).

3. Omnibus test of joint independence of all the covariates from the treatment assignment, presented in the last rows of Tables A2 and A3. This is conducted using a randomization inference procedure:

    - We obtain the likelihood ratio statistic from a multinomial logistic regression of treatment assignment on the covariates.
    - We permute the random assignment 1,000 times according to the original random assignment protocol.
    - We obtain the likelihood ratio statistics from regressions of these 1,000 simulated treatment assignments on the covariates.
    - We construct a p-value by observing the frequency with which the simulated statistics exceed the observed statistic.

Table A2: Experiment 1 Balance

	Treatment Assignment			
	Public Tweet	Follower	Organizer	*p*-value
Account Type: Female	0.309	0.287	0.307	
	(0.008)	(0.012)	(0.012)	
Account Type: Male	0.381	0.375	0.401	
	(0.008)	(0.013)	(0.013)	
Account Type: Organization	0.245	0.254	0.230	
	(0.007)	(0.011)	(0.011)	
Account Type: Unknown	0.065	0.083	0.061	
	(0.004)	(0.007)	(0.006)	0.072
Number of Followers	596.240	616.603	635.733	
	(14.146)	(22.099)	(23.357)	0.312
Days on Twitter	1631.438	1637.362	1637.179	
	(8.983)	(14.189)	(14.153)	0.910
Eigenvector Centrality	0.039	0.038	0.038	
	(0.001)	(0.002)	(0.002)	0.960
N	3687	1500	1500	

Omnibus *p*-value: 0.607

Table A3: Experiment 2 Balance

	Treatment Assignment			
	Public Tweet	Follower	Organizer	*p*-value
Account Type: Female	0.315	0.329	0.348	
	(0.008)	(0.009)	(0.010)	
Account Type: Male	0.405	0.392	0.379	
	(0.008)	(0.010)	(0.010)	
Account Type: Organization	0.224	0.222	0.214	
	(0.007)	(0.008)	(0.008)	
Account Type: Unknown	0.056	0.056	0.059	
	(0.004)	(0.005)	(0.005)	0.425
Number of Followers	585.599	580.738	581.281	
	(14.469)	(16.999)	(16.996)	0.535
Number of Tweets	1559.503	1554.428	1552.586	
	(10.067)	(12.131)	(11.988)	0.601
Eigenvector Centrality	0.032	0.031	0.030	
	(0.001)	(0.001)	(0.001)	0.537
N	3495	2498	2514	

Omnibus *p*-value: 0.113

Appendix 3: Heterogeneous Effects of Treatment

Table A4: Study 1: Heterogeneous Effects of Treatments

	signed				tweeted			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Treatment: Follower	0.039***	0.039***	0.039***	0.053***	0.027***	0.027***	0.027***	0.028***
	(0.005)	(0.005)	(0.005)	(0.011)	(0.004)	(0.004)	(0.004)	(0.008)
Treatment: Organizer	0.033***	0.033***	0.033***	0.048***	0.016***	0.016***	0.016***	0.015***
	(0.005)	(0.005)	(0.005)	(0.010)	(0.003)	(0.003)	(0.003)	(0.006)
Eigenvector Centrality	0.000				0.000			
	(0.000)				(0.000)			
Follower X Centrality	−0.006*				−0.003			
	(0.003)				(0.002)			
Organizer X Centrality	0.006				−0.002*			
	(0.009)				(0.001)			
Number of Followers		0.000				0.000		
		(0.000)				(0.000)		
Follower X Followers		−0.005*				−0.004		
		(0.003)				(0.003)		
Organizer X Followers		−0.002				−0.003		
		(0.004)				(0.002)		
Days on Twitter			0.000				0.000	
			(0.000)				(0.000)	
Follower X Days on Twitter			−0.002				−0.004	
			(0.006)				(0.005)	
Organizer X Days on Twitter			0.001				0.000	
			(0.005)				(0.003)	
Account Type: Male				0.000				0.000
				(0.000)				(0.000)
Account Type: Organization				0.000				0.000
				(0.000)				(0.000)
Account Type: Unknown				0.000				0.000
				(0.000)				(0.000)
Follower X Male				−0.005				−0.001
				(0.014)				(0.010)
Organizer X Male				−0.011				0.005
				(0.013)				(0.008)
Follower X Organization				−0.043***				−0.007
				(0.012)				(0.011)
Organizer X Organization				−0.036***				−0.006
				(0.011)				(0.008)
Follower X Unknown				−0.013				0.020
				(0.021)				(0.021)
Organizer X Unknown				−0.026				0.007
				(0.018)				(0.016)
Constant	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
N	6,687	6,687	6,687	6,687	6,687	6,687	6,687	6,687
R^2	0.022	0.021	0.021	0.027	0.014	0.014	0.014	0.015

*p < .1; **p < .05; ***p < .01
Robust standard errors in parentheses.
Eigenvector centrality, Number of Followers, and Days on Twitter in standard units and centered at zero

Table A5: Study 2: Heterogeneous Effects of Treatments

	signed				tweeted			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Treatment: Follower	0.046***	0.046***	0.046***	0.044***	0.014***	0.014***	0.014***	0.010***
	(0.004)	(0.004)	(0.004)	(0.007)	(0.002)	(0.002)	(0.002)	(0.003)
Treatment: Organizer	0.042***	0.043***	0.043***	0.053***	0.011***	0.011***	0.011***	0.010***
	(0.004)	(0.004)	(0.004)	(0.008)	(0.002)	(0.002)	(0.002)	(0.003)
Eigenvector Centrality	0.000				0.000			
	(0.000)				(0.000)			
Follower X Centrality	−0.002				0.001			
	(0.003)				(0.002)			
Organizer X Centrality	−0.006**				−0.001*			
	(0.003)				(0.001)			
Number of Followers		0.000				0.000		
		(0.000)				(0.000)		
Follower X Followers		−0.001				0.003		
		(0.004)				(0.003)		
Organizer X Followers		−0.004				0.003		
		(0.003)				(0.003)		
Days on Twitter			0.000				0.000	
			(0.000)				(0.000)	
Follower X Days on Twitter			−0.002				−0.001	
			(0.005)				(0.003)	
Organizer X Days on Twitter			0.000				−0.002	
			(0.004)				(0.002)	
Account Type: Male				0.000				0.000
				(0.000)				(0.000)
Account Type: Organization				0.000				0.000
				(0.000)				(0.000)
Account Type: Unknown				0.000				0.000
				(0.000)				(0.000)
Follower X Male				0.019*				0.010*
				(0.011)				(0.006)
Organizer X Male				−0.001				0.007
				(0.010)				(0.005)
Follower X Organization				−0.026***				0.001
				(0.009)				(0.006)
Organizer X Organization				−0.038***				−0.007
				(0.009)				(0.004)
Follower X Unknown				0.006				0.012
				(0.020)				(0.013)
Organizer X Unknown				−0.026*				−0.004
				(0.015)				(0.008)
Constant	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
N	8,507	8,507	8,507	8,507	8,507	8,507	8,507	8,507
R^2	0.019	0.019	0.019	0.025	0.006	0.006	0.006	0.007

*p < .1; **p < .05; ***p < .01

Robust standard errors in parentheses.

Eigenvector centrality, Number of Followers, and Days on Twitter in standard units and centered at zero

Appendix 4: Experimental Materials

Figure A1: A screenshot of the tweet encouragement randomly shown to respondents in either of the DM conditions who completed the online petition.

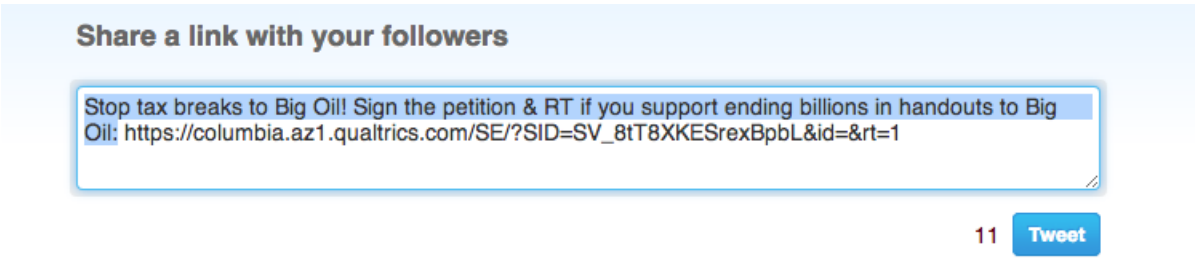

Figure A2: A screenshot of the pop-up window shown to respondents who clicked the tweet button.

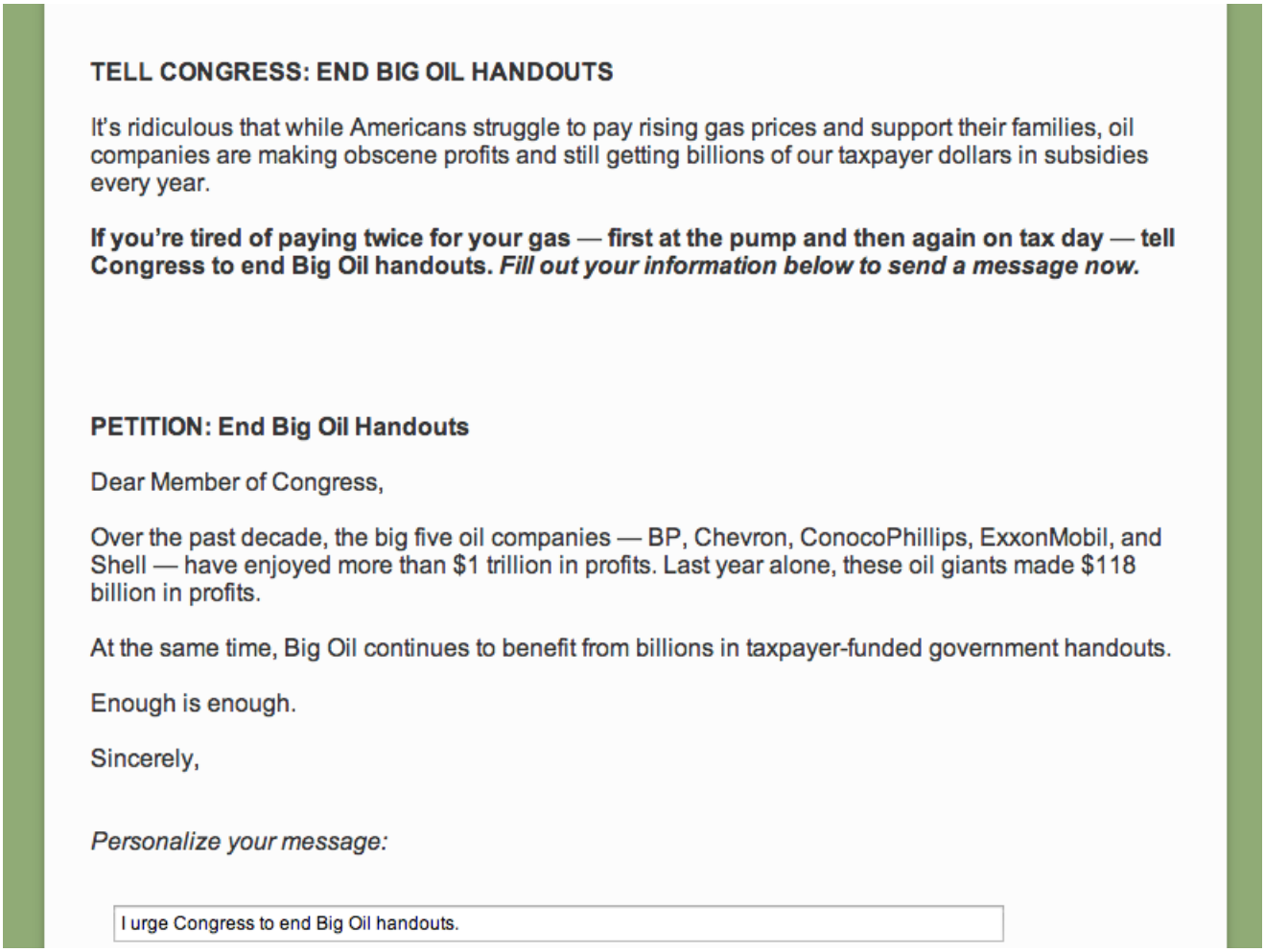

Figure A3: The top half of the online petition whose link was sent to subjects in the DM conditions in Study 1.

SUPPORT THE EPA'S BIGGEST ACTION EVER ON CLIMATE CHANGE!

The Obama administration has proposed a critical plan to limit carbon pollution from new and existing power plants that fuels global warming. Currently, we limit how much mercury, arsenic, soot and other pollutants power plants dump into our air. But if the Koch brothers, the coal industry, and congressional climate change deniers have their way, polluters will continue to have free rein to dump unlimited amounts of harmful carbon pollution into our air.

The Environmental Protection Agency (EPA) has been working on commonsense carbon limits for power plants, but lobbyists, corporate polluters and Washington insiders are working tirelessly to stop this progress in its tracks. By signing a petition in support of the EPA's efforts, however, you can give the EPA the support it needs to stand up to the polluters.

Sign this petition to the EPA today, and your voice will be heard. Don't miss the chance to help make a huge impact on the fight for our planet's future -- *fill out your information here to support this critical climate change action now.*

PETITION: Cut Carbon Pollution From Power Plants

Dear EPA Administrator McCarthy,

I strongly support the EPA's effort to limit carbon pollution from existing power plants.

Personalize your message:

Figure A4: The top half of the online petition whose link was sent to subjects in the DM conditions in Study 2.

Figure A5: The public tweet from Study 1.

Figure A6: The public tweet from Study 2.

Appendix 5: Privacy and Ethical Considerations

Our research design presents ethical challenges common to field experiments implemented in online environments. In particular, like much unobtrusive field research, we could not obtain informed consent from subjects without compromising our inferential strategy. In proceeding with these studies, we relied on our own judgment that the benefits of the study outweighed any risks to subjects.

Furthermore, since most Twitter activity is public by design, we took a series of steps to protect subjects' anonymity. To ensure that our approach toward consent and privacy met common standards for minimizing any potential harm, we obtained IRB approval from one of the authors' home institutions [details withheld]. Below, we detail several considerations that we believe are crucial to evaluating the ethics of the experiments reported here (as well as others with similar designs).

Twitter's Policies

Twitter's privacy policy, available at `https://twitter.com/privacy`, explicitly informs users that their public profile information and tweets are made immediately available to third parties, including research institutions:

> For instance, your public user profile information and public Tweets are immediately delivered via SMS and our APIs to our partners and other third parties, including search engines, developers, and publishers that integrate Twitter content into their services, and institutions such as universities and public health agencies that analyze the information for trends and insights. When you share information or content like photos, videos, and links via the Services, you should think carefully about what you are making public.

This policy, part of the terms of service for all users, ensures that collecting public tweet data is firmly within the bounds of reasonable use.

Data Privacy

LCV's experience mobilizing its members while protecting their privacy generally assuaged our concerns. We acknowledge, however, that in collecting data for this study we make public information somewhat more accessible. No individual tweets are revealed in the study, and personally identifiable information such as user names, descriptions, network connections, and location have been removed from all replication files.

Organization's Goals

A final concern regards the nature of the manipulation. The messages used in both studies were approved by LCV as part of ongoing social media campaigns directly related to its core goals. As shown in Section 4,

LCV posts approximately 6 tweets or retweets per weekday on average; the public tweet component of the experiments' design was designed to fit in with the organization's existing day-to-day engagement strategy.

Private direct messages (DM) are less commonly used by organizations, but practically speaking these are no more intrusive than a mass email message. In this case, by signing up for Twitter and voluntarily following LCV's account, subjects assigned to receive a DM in effect opted to receive communications from the latter via the former.

However, we do not take these concerns lightly. Despite the fact that both studies' messages were part of a preexisting social media campaign, we acknowledge that the DM treatments comprised an unorthodox communications strategy. The petitions may also have taken several minutes of subjects' time. In response, we note that LCV's follower count has continued to rise and that we find no evidence of a backlash effect of any kind.

References

Fisher RA (1925) Statistical Methods for Research Workers. London: Oliver and Boyd